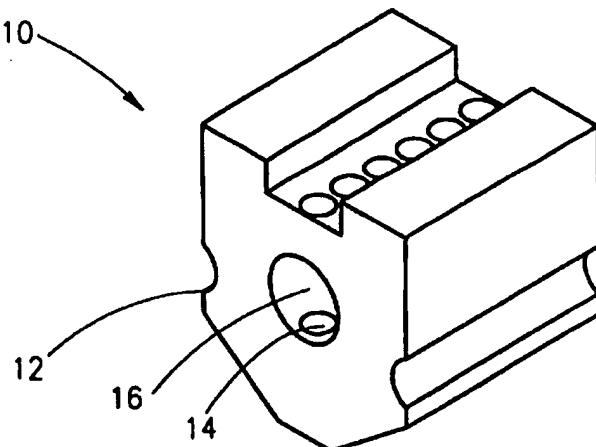




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : <b>B41J 2/02, 2/07, 2/045, 2/085, 2/14, 2/16</b>		A1	(11) International Publication Number: <b>WO 97/42034</b> (43) International Publication Date: 13 November 1997 (13.11.97)
<p>(21) International Application Number: <b>PCT/IL97/00139</b></p> <p>(22) International Filing Date: 30 April 1997 (30.04.97)</p> <p>(30) Priority Data: 08/642,192 6 May 1996 (06.05.96) US</p> <p>(71) Applicant: JEMTEX INK JET PRINTING LTD. [IL/IL]; Tevuot Haaretz Street 3, 61241 Tel Aviv (IL).</p> <p>(72) Inventor: SHEINMAN, Yoshua; Shlonsky Street 21, 43592 Ra'anana (IL).</p> <p>(74) Agent: A. TALLY EITAN - ZEEV PEARL, D. LATZER &amp; CO.; Law Offices, Lumir House, Maskit Street 22, 46733 Herzlia (IL).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p>Published <i>With international search report.</i></p>	
<p>(54) Title: A PRINTING FLUID MULTI-JET GENERATOR AND METHOD FOR PRINTING USING SAME</p> <p>(57) Abstract</p> <p>A printing method which includes the steps of providing a stream of a printing fluid, forming a plurality of jets of the printing fluid from the stream, each jet having a predetermined direction, generating printing fluid droplets from each of the jets, the printing fluid droplets having the same predetermined direction. In the preferred embodiment the step of generating includes the step of substantially simultaneously perturbing the pressure of the jets. The method also includes the step of deviating selected ones of the ink droplets from the predetermined direction, thereby forming a pattern of ink droplets forming an image on a printing substrate. According to the present invention, a printing apparatus (400) employing the printing method includes at least one plurality of printing fluid multi-jet generators (10) connected therebetween, each multi-jet generator (10) includes a plurality of channels (14), each of which for generating a printing fluid jet (17) having a predetermined direction therefrom, a printing fluid reservoir (16) connecting the plurality of channels (14) of substantially all the plurality of multi-jet generators (10) for providing a stream (15) of the printing fluid to each of the plurality of channels (14) of the plurality of multi-jet generators (10) whereby the printing fluid jet (17) forms a plurality of printing fluid droplets (19), and a printing fluid droplets deviation unit (306) operative downstream the plurality of multi-jet generators (10) for deviating selected ones of the printing fluid droplets (328) from the predetermined direction, thereby forming a pattern of the printing fluid droplets (332) forming an image (330) on a printing substrate (308).</p>			



(10) connected therebetween, each multi-jet generator (10) includes a plurality of channels (14), each of which for generating a printing fluid jet (17) having a predetermined direction therefrom, a printing fluid reservoir (16) connecting the plurality of channels (14) of substantially all the plurality of multi-jet generators (10) for providing a stream (15) of the printing fluid to each of the plurality of channels (14) of the plurality of multi-jet generators (10) whereby the printing fluid jet (17) forms a plurality of printing fluid droplets (19), and a printing fluid droplets deviation unit (306) operative downstream the plurality of multi-jet generators (10) for deviating selected ones of the printing fluid droplets (328) from the predetermined direction, thereby forming a pattern of the printing fluid droplets (332) forming an image (330) on a printing substrate (308).

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## A PRINTING FLUID MULTI-JET GENERATOR AND METHOD FOR PRINTING USING SAME

### FIELD OF THE INVENTION

The present invention relates to apparatus and method for multi-jet ink generation for ink jet printing heads incorporated in ink jet printers generally and more particularly to apparatus and method for multi-jet ink generation employing pressure perturbation.

### BACKGROUND OF THE INVENTION

Ink jet printers employ various physical forces to take small quantities of ink from a reservoir, convert them into droplets, and transport the droplets through the air to the printing medium, such as paper, transparencies, metal, glass etc. The forces used to create and transport the droplets may be mechanical, electrostatic or thermal. Ink jet printers fall into two main categories -- continuous-jet and drop-on-demand.

In both types of devices, droplets are formed by forcing a printing fluid, or ink, through a nozzle. Hence, the ink-jet devices typically include a multitude of very small diameter nozzles. Drop-on-demand systems typically use nozzles having openings ranging from 30 to 100  $\mu\text{m}$  while Hertz continuous-jet systems typically use nozzles having openings ranging from only 10-20  $\mu\text{m}$ .

The use of such nozzles leads to a number of difficulties, not the least of which is the relatively high incidence of nozzle clogging, high cost of manufacture, the requirement for tight tolerances and strict materials limitations. To avoid nozzle clogging and increase the reliability of such printers, high-grade fine filters must be used upstream of the nozzle to avoid dirt particles in the ink from reaching the nozzle. Furthermore, during the time printer is not in use, the ink should not dry in the nozzle since a solid deposit will also result in clogging. To avoid this difficulty a humectant is used in the ink to prevent the ink from drying except when it contacts the paper. The ink must also contain fungicides to prevent biological growth which could result in nozzle clogging by fungi or bacteria. To obtain ink of a required color, a suitable dye must be added to the ink. Color pigments cannot be used since they clog the nozzle or the filter. The choice of dye is critical since the dye must not form a solid deposit with the humectant if the ink is allowed to dry in the nozzle.

All these strict requirements relating to the inks, severely limit the choice of inks which may be used in ink-jet systems using nozzles. Much research has been devoted to optimizing ink compositions in an attempt to find inks which have suitable characteristics. Typically, an ink found to be suitable represents a number of tradeoffs and compromises with respect to a series of properties.

## SUMMARY OF THE INVENTION

It is therefore an object of the present invention is to provide a multi-jet generator for applying printing fluids on a printing substrate.

5 A further object of the present invention is to provide an improved printing apparatus which includes a plurality of the multi-jet generators of the present invention.

Yet a further object of the present invention is to provide an improved printing system which includes a number of the printing apparatus of the present invention.

10 According to one aspect of the present invention, the multi-jet generator is constructed so as to operate with a wide variety of ink composition, such as UV-curable pigment containing inks.

15 According to a further aspect of the present invention, the printing apparatus provides a matrix of streams of printing fluid, each of which converges into a jet of printing fluid which, in turn, is broken into droplets in a controlled fashion. The droplets thus formed can be employed for non-contact printing of a printing substrate.

There is thus provided, in accordance with a preferred embodiment of the present invention, a printing method which includes the steps of:

20 A. providing a stream of a printing fluid;  
B. forming a plurality of jets of the printing fluid from the stream, each jet having a predetermined direction;  
C. generating printing fluid droplets from each of the jets, the printing fluid droplets having the same predetermined direction, the step of generating includes  
25 the step of substantially simultaneously perturbing the pressure of the jets; and  
D. deviating selected ones of the ink droplets from the predetermined direction, thereby forming a pattern of ink droplets forming an image on a printing substrate.

Further, in a preferred embodiment the step of providing includes the  
30 step of inputting the printing fluid in a direction generally perpendicular to the predetermined direction. Still further the step of providing may also include the step of inputting the printing fluid into a printing fluid reservoir and wherein the stream being formed from the printing fluid reservoir.

In accordance with a preferred embodiment of the present invention, the  
35 step of perturbing includes the step of increasing the pressure, from a generally

constant operation pressure and decreasing the pressure generally to the constant operation pressure and repeating the increasing and decreasing a desired plurality of times.

5 Preferably, the steps of increasing and decreasing include the step of vibrating the stream of printing fluid. In an alternative preferred embodiment, the steps of increasing and decreasing include the step of shaking the plurality of jets.

10 In accordance with yet a further preferred embodiment, the method may also include the step of controlling a rate of the step of generating printing fluid droplets by changing the pressure of the jet of printing fluid, the change in pressure in accordance with a change in a frequency of the vibration or the shaking.

Further, the step of deviating includes the steps of charging selected ones of the printing fluid droplet not included in the pattern, and deflecting the charged printing fluid droplets from the predetermined direction.

15 There is also provided in accordance with the present a printing fluid channel which includes an inlet section having a narrowed section in an outlet end thereof for increasing stream velocity downstream therefrom, an outlet section having an aperture, and a chamber disposed between the narrowed section and the aperture for generating a jet of printing fluid from the stream of printing fluid. In 20 a preferred embodiment, the aperture is substantially smaller than the narrowed section.

In accordance with a preferred embodiment of the present invention, the chamber is generally cylindrical in shape and the outlet section is generally conical in shape and the narrowed section is generally shaped as an O-ring.

25 There is also provided, in accordance with a preferred embodiment of the present invention a printing fluid multi-jet generator which includes a printing fluid reservoir for providing a stream of printing fluid and a plurality of the channels of the present invention.

30 In a preferred embodiment, the printing fluid reservoir and the plurality of channels are generally perpendicular and the distance between adjacent ones of the plurality of channels is substantially similar.

35 Further, according to the present invention, the multi-jet generator may also include a vibration unit for vibrating the multi-jet generator, thereby perturbing the pressure in the plurality of channels, whereby breakage of the printing fluid jets into printing fluid droplets is induced. In a preferred embodiment, the vibration

unit includes a piezoelectric transducer external to the printing fluid reservoir and operative to vibrate a pedal within the printing fluid reservoir.

There is also provided, in accordance with yet a further preferred embodiment of the present invention, a printing apparatus which includes at least 5 one plurality of the printing fluid multi-jet generators of the present invention connected therebetween,

a printing fluid reservoir connecting the plurality of channels of substantially all the plurality of multi-jet generators for providing a stream of the printing fluid to each 10 of the plurality of channels, a vibration unit for generating a pressure perturbation in each of the plurality of channels of the plurality of multi-jet generators whereby the printing fluid jet forms a plurality of printing fluid droplets, and a printing fluid droplets deviation unit operative downstream the plurality of multi-jet generators for deviating selected ones of the printing fluid droplets from the predetermined direction, thereby forming a pattern of the printing fluid droplets forming an image 15 on a printing substrate.

In a preferred embodiment, the vibration unit is operative to vibrate the printing apparatus, thereby shaking the printing fluid, wherein the shaking generates the pressure perturbation. Accordingly, the vibration unit includes a first plate connected to the at least one plurality of multi-jet generators, a second plate, 20 a plurality of mountings disposed intermediate the first plate and the second plate, and a piezoelectric transducer also disposed intermediate the first plate and the second plate, wherein the natural frequency of the plurality of mountings is smaller than that of the piezoelectric transducer.

Alternatively, the vibration unit is an external piezoelectric transducer 25 operative to vibrate the printing fluid in the printing fluid reservoir or a piezoelectric transducer external to the printing fluid reservoir and operative to vibrate a pedal within the printing fluid reservoir.

Finally, according to the present invention the droplets deviation unit 30 includes a charging unit for charging selected ones of the printing fluid droplet not included in the pattern and a deflection unit for deflecting the charged printing fluid droplets from the predetermined direction.

### BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the appended drawings in which:

5 Fig. 1A is a schematic isometric illustration of a multi-jet generator, constructed and operative in accordance with a first embodiment of the present invention;

Fig. 1B is a schematic cross section illustration through one of the channels of the multi-jet generator of Fig. 1A;

10 Fig. 2 is a schematic isometric illustration of a multi-jet printing apparatus; constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 3 illustrates the printing apparatus of Fig. 2 with an external vibration unit;

15 Fig. 4A is a schematic cross section illustration through one of the channels of the multi-jet generator of Fig. 1A with an internal vibration unit;

Figs. 4B and 4C are schematic isometric illustrations of a printing unit of the printing apparatus of Fig. 2 with an external vibration unit and an external vibration unit for each multi-jet generator, respectively;

20 Fig. 5A is a schematic cross section illustration of the selective charging and deflection unit of a printing unit of the printing apparatus of Fig. 2;

Figs. 5B and 5C are detailed schematic cross section illustrations of the two embodiments of the selective charging and deflection unit of Fig. 5A;

25 Fig. 6 is a schematic block diagram illustration of the printing method of the present invention; and

Fig. 7 is a schematic cross section illustration of a printing system which includes a plurality of the multi-jet printing apparatus of Fig. 2.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference is now made to Figs. 1A through 1C which illustrate a multi-jet generator, generally referenced 10, constructed and operative according to a preferred embodiment of the present invention. Multi-jet generator 10 provides streams of printing fluid which converge into jets of printing fluid which, in turn, are broken up into droplets which are selectively charged and deflected downstream from generator 10. The term "stream of printing fluid", hereinafter also "stream", refers throughout the specification and claims to a two-dimensional flow of printing fluid and the term "jet of printing fluid", hereinafter also "jet", refers throughout the specification and claims to a uni-directional flow of printing fluid.

Multi-jet generator 10 comprises a member 12 having a plurality of channels 14 formed therethrough and a printing fluid reservoir 16 which connects the plurality of channels therebetween. In the illustrated embodiment, printing fluid reservoir 16 is generally perpendicular to channels 14. As best seen in Fig. 1B., each channel 14 provides a single vertical stream 15 which converges into a vertical jet 17 from which printing fluid droplets 19 are formed. In the illustrated embodiment, channels 14 are spaced in generally equal distances one from the other so as to provide ink droplets 19 in a predetermined resolution.

Each channel 14 comprises an inlet section 18 adjacent and in connection with printing fluid reservoir 16, an outlet section 20 and a printing fluid stream chamber 22 disposed therebetween.

In a preferred embodiment, channels 14 are produced by forming a hollow through member 12 and using a cap 21 to close each of channels 14 above printing fluid reservoir 16.

In the illustrated embodiment, chamber 22 is cylindrical in shape and outlet section 20 is conical in shape with an aperture at its end. Thus the dimension, i.e. the diameter of chamber 22 is generally similar therealong and is larger than the decreasing diameter of outlet 20. Preferably, a narrowing device 24 is disposed in the entrance into chamber 22, the narrowed section increases the velocity of stream 15 downstream therefrom, i.e. in chamber 22. In the illustrated embodiment, narrowing device 24 is shaped as an O-ring and supported by protrusion 26. In the preferred embodiment, the aperture at the end of outlet 20 is substantially smaller than that of the narrowed section formed by narrowing device 24.

It will be appreciated that each multi-jet generator 10 is connectable to any number of other multi-jet generators so as to form a printing apparatus as shown in Fig. 2 to which reference is now made.

Fig. 2 illustrates a printing apparatus, generally referenced 100, which comprises at least one plurality of multi-jet generators 10 connected therebetween. In the illustrated embodiment, printing apparatus 100 comprises three pluralities of multi-jet generators 10, individually referenced 102A, 102B and 102N, and collectively termed hereinafter printing units 102. It will be appreciated that three printing units are shown as a non limiting example.

As illustrated for printing unit 102A, each printing unit comprises a plurality of multi-jet generators 10 connected therebetween and forming a single reservoir for the entire unit, generally referenced 116. As best seen for printing unit 102N, multi-jet generators 10 may be connected via connectors 104 to form the single reservoir 116.

Printing apparatus 100 further comprises a vibration unit described in detail with reference to Figs. 3 through 4C hereinbelow for vibrating printing units 102 separately or collectively, thereby generating a pressure perturbation in the printing unit for whereby the printing fluid jet forms a plurality of printing fluid droplets and a printing fluid droplets deviation unit 106 operative downstream the plurality of multi-jet generators 10 for deviating selected ones of the printing fluid droplets from their predetermined direction, thereby forming a pattern of the printing fluid droplets forming an image on a printing substrate as described in detail with reference to Figs. 5A through 5C hereinbelow.

Referring now to Fig. 3, printing apparatus 100 is illustrated with a vibration unit 110. Vibration unit 110 comprises a first plate 112, connected to printing units 102A, 102B and 102N, a second plate 114, spaced away from plate 112 and connected to an external support (not shown), a vibration device 118 and mountings 120. In a preferred embodiment, vibration device 118 is a piezoelectric transducer and mountings 120 are relatively soft mountings having self vibration frequency which is lower, and preferably substantially lower than the vibration frequency of the piezoelectric transducer.

In operation, printing units 102 have a constant operation pressure. Then, vibration device 118 vibrates as indicated by arrows 122, the vibration shakes the printing units 102 so as to collectively increase the pressure in channels 14. The increase in pressure induces breakage of jet 17 into droplets 19

which a portion representing an image to be printed is subsequently applied to printing substrate 130.

It will be appreciated that the size of the generated printing fluid droplets depend on their physicochemical properties (e.g. viscosity) on their velocity 5 absent additional pressure and on the frequency of vibration of vibrating device 118, therefore the size of droplets 19 may be controlled by changing the frequency of vibration of vibration device 118.

It will also be appreciated that vibration device 118 vibrates printing apparatus 100 and not the fluid therein. Alternatively, the fluid itself can be 10 vibrated as shown in Fig. 4A to which reference is now made. In the embodiment of Fig. 4A, a piezoelectric transducer 126 is connected to a pedal 128 disposed intermediate reservoir 16 so as to induce vibration therein as indicated by arrow 129 substantially simultaneously in all channels 14, thereby inducing the breakage of jets 17 into droplets 19 in all the channels.

15 In yet another preferred embodiment, the fluid stream to each printing unit is being vibrated so as to increase the pressure in reservoir 116 and channels 14 so as to induce breakage of jets 17 into droplets 19 substantially simultaneously in all channels. In the embodiment illustrated in Fig. 4B, an external vibration unit 138 vibrates by any suitable means, such as a piezoelectric 20 transducer, in the direction indicated by arrows 140. This lateral vibration effects the pressure in reservoir 116 (Fig. 2) as described hereinabove. In the embodiment of Fig. 4C, each multi-jet generator 10 includes a vibration devices 148 which is operative to induce the added pressure for inducing breakage of jets 17 into droplets 19 substantially simultaneously for all channels.

25 Reference is now made to Figs. 5A - 5C which illustrate deviation unit 106 and its operation. Deviation unit 106 comprises a charging unit 202 and a deflection unit 204.

Charging unit 202 is operative to selectively charge printing fluid droplets which are not to be applied on printing substrate 130 wherein deflection unit 204 30 is operative to deflect the charged droplets to a collection system (not shown). In the illustrated embodiment, printing droplets deviation units 106 are disposed on opposite sides of the printing droplets formed by each printing units 102 (Fig. 2), thus each unit 106 is operative on two printing fluids droplets as described hereinbelow.

35 Each charging unit 202 comprises two electrodes, a positively charged electrode, referenced 212 or 232, and a negatively charged electrode 222. As

illustrated in Fig. 5A, the electrodes are arranged so that the positively charged electrode 212 on one unit 202 faces the negatively charged electrode 222 of its adjacent electrode.

Unit 202 may also include an illumination source 206, such as a Light Emitting Diode (LED) source and a detection unit 208, such as a diode, for detecting light reflected by droplet 230.

In one preferred embodiment, shown in the left and right units 202 and in greater details in Fig. 5B, illumination source 206 and detector 208 form a single unit and the positively charged electrode is formed as a wire 232 common to all channels of the printing unit. Alternatively, as shown in the center unit 202 (Fig. 5A) and in greater detail in Fig. 5C, illumination source 206, detector 208 and positively charged electrode 212 are separate.

In operation, once a first droplet 230 crosses the illumination beam of LED 206 the light is reflected therefrom and is detected by detector 208 so as to set a timing for each droplet which is used to control the operation of electrodes 212 and 222 in an information wise manner. Alternatively, illumination device 206 and detection device 208 are on opposite sides of the jet, in which case detector 208 detects the light absorbed by droplet 230.

Preferably, illumination source 206 is operative to illuminate the printing droplets with a color insensitive radiation, such as an Infra Red radiation of suitable wavelength so that the system will not depend on the color of the printing droplet.

The operation of multi-jet generator 10 and each printing unit 102 of printing apparatus 100 is now described with reference also to Fig. 6. The method preferably includes three major steps, the step of forming a jet of a printing fluid in a predetermined direction which take place in each channel 14 (step 302), the step of generating ink droplets from the jet of printing fluid in the same predetermined direction which takes place in the open air as indicated by 304 and the step of deviating selected ones of the ink droplets from the predetermined direction which takes place in the ink droplets deviation unit as indicated by 306 and the printing step in which a pattern of ink droplets forming an image to be printed on a printing substrate to be printed as indicated by 308.

The step of generating a printing jet comprises the step of forming a printing stream 310 which is converted in the open air to a unidirectional printing jet. In a preferred embodiment, a printing fluid inflow is inputted (step 312) into the

printing fluid reservoir 16 (Fig. 1B) or 116 (Fig. 2) as indicated by block 314, the output from which forms the stream of printing fluid as indicated by block 316.

According to a preferred embodiment of the present invention, the printing fluid in reservoir is perturbed as described in detail with reference to Figs.

5 3 through 4C hereinabove so as to control the rate of ink droplets generation from the printing jet.

According to the pressure perturbation, the printing jet travels as indicated by step 318 in a preferred predetermined direction, preferably downwards as indicated by arrow 320 so as to form ink droplets 322 having same 10 predetermined direction.

In order to effect printing, the ink droplets are selectively being charged (step 324) while traveling in the predetermined direction 320 for subsequent selective deflection thereof (step 326) as described in detail with reference to Figs. 5A through 5C hereinabove so as to deviate the ink droplets which do not 15 form part of the printed image as indicated by arrow 328.

The droplets not being deflected at 326 impinge the printed substrate, thereby forming the printed image as indicated by 330 and arrow 332.

Reference is now made to Figure 7, which illustrates a printing system, generally referenced 400, which comprises a printing apparatus 100 for each color to be printed. In the illustrated embodiment, printing system 400 is a four color process colors, Cyan, Magenta, Yellow and Black (CMYK or CMYB) printing system which correspondingly comprises a printing apparatus 100C, 100M, 100Y and 100K for printing the CMYK colors, respectively. Typically each multi-jet generator 10 can provide 50 dots per inch (dpi) and therefore each color head, for example, color head 100C, includes four staggered printing units 102 to effect high resolution single-pass color printing of 200 dpi. Between each printing apparatus 100C, 100M, 100Y and 100K, the printing medium may be treated in some desirable fashion. For example, when UV-curable ink is used, an UV lamp 103 may be located following each printing unit 102 in order to fix the most recently used color.

Printing system 400 can be used to print, mark and/or plot on various printing substrates, including paper, glass, plastic, metal and fabric. Printing system 400 is particularly suitable for large format printing by virtue of the static nature of the multi-jet generators 10. Any suitable method of creating a variety of different colors can be used. One such scheme involves placing dots of different colors in the immediate vicinity of dots of different colors so as to form the visual

perception in the mind of the viewer of a new color, much the way this is accomplished in half toning techniques.

All in all, printing system 400 integrating multi-jet generator devices of the present invention offers a number of advantages over conventional continuous ink jet technology. First, the multi-jet generator device according to the present invention includes few moving parts, is inherently reliable and trouble free, and is less expensive to build than conventional devices which require a multitude of precision-made nozzles. Second, the multi-jet generator device features little or no interaction between adjoining jets. And third, the multi-jet generator device is able to use a greatly enlarged group of printing fluids, including photo-polymers (such as UV-curable ink) which are shear-sensitive and cannot normally be passed through small diameter nozzles without polymerizing or otherwise degrading. Furthermore, feed of printing fluids is considerably simplified.

It will be appreciated that the preferred embodiments described hereinabove are described by way of example only and that numerous modifications thereto, all of which fall within the scope of the present invention, exist.

It will also be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described herein above. Rather the scope of the invention is defined by the claims which follow:

**CLAIMS**

1. A printing method comprising the steps of:
  - a. providing a stream of a printing fluid;
  - b. forming a plurality of jets of said printing fluid from said stream, each jet having a predetermined direction;
  - c. generating printing fluid droplets from each of said jets, said printing fluid droplets having said same predetermined direction, said generating comprising the step of substantially simultaneously perturbing the pressure of said jets; and
  - d. deviating selected ones of said ink droplets from said predetermined direction, thereby forming a pattern of ink droplets forming an image on a printing substrate.
2. A method according to claim 1 wherein said providing comprises inputting said printing fluid in a direction generally perpendicular to said predetermined direction.
3. A method according to claim 1 wherein said providing comprises inputting said printing fluid into a printing fluid reservoir and wherein said stream being formed from said printing fluid reservoir.
4. A method according to claim 1 wherein said perturbing comprises increasing said pressure, from a generally constant operation pressure and decreasing said pressure generally to said constant operation pressure and repeating said increasing and decreasing a desired plurality of times.
5. A method according to claim 4 wherein said increasing and decreasing comprises vibrating said stream of printing fluid.
6. A method according to claim 4 wherein said increasing and decreasing comprises shaking said plurality of jets.
7. A method according to any of claims 5 or 6 further comprising the step of controlling a rate of said generating printing fluid droplets by changing said pressure of said jet of printing fluid, said change in pressure in accordance with a change in a frequency of said vibration.

8. A method according to claim 1 wherein said step of deviating comprises:

- a. charging selected ones of said printing fluid droplets not included in said pattern; and
- 5 b. deflecting said charged printing fluid droplets from said predetermined direction.

9. A printing fluid channel comprising:

- a. an inlet section having a narrowed section in an outlet end thereof for increasing stream velocity downstream therefrom;
- 10 b. an outlet section having an aperture; and
- c. a chamber disposed between said narrowed section and said tip for generating a jet of printing fluid from said stream of printing fluid.

10. A printing fluid channel according to claim 9 wherein said chamber is generally cylindrical in shape and said outlet section is generally conical in shape.

11. A printing fluid channel according to any of claims 9 - 10 wherein said narrowed section is generally shaped as an O-ring.

12. A printing fluid multi-jet generator comprising:

- 20 a. a printing fluid reservoir for providing a stream of printing fluid;
- b. a plurality of channels, each channel comprising an inlet section having a narrowed section in an outlet end thereof for increasing stream velocity downstream therefrom, an outlet section having an aperture, and a chamber disposed between said narrowed section and said aperture for generating a jet of printing fluid from said stream.

25 13. A multi-jet generator according to claim 12 wherein said printing fluid reservoir and said plurality of channels are generally perpendicular.

14. A multi-jet generator according to claim 12 wherein the distance 30 between adjacent ones of said plurality of channels is substantially similar.

15. A multi-jet generator according to claim 12 wherein said narrowed section is a narrowing device.
16. A multi-jet generator according to claim 15 wherein said narrowing device is generally shaped as an O-ring.
- 5 17. A multi-jet generator according to claim 12 wherein said chamber is generally cylindrical in shape and said outlet section is generally conical shape.
- 10 18. A multi-jet generator according to any of claims 12 - 17 and also comprising a vibration unit for vibrating said multi-jet generator, thereby perturbing the pressure in said plurality of channels, whereby breakage of said printing fluid jets into printing fluid droplets is induced.
- 15 19. A multi-jet generator according to claim 18 wherein said vibration unit comprises a piezoelectric transducer external to said printing fluid reservoir and operative to vibrate a pedal within said printing fluid reservoir.
- 20 20. A printing apparatus comprising:
  - a. at least one plurality of printing fluid multi-jet generators connected therebetween, each multi-jet generator comprising a plurality of channels, each of which for generating a printing fluid jet having a predetermined direction therefrom;
  - b. a printing fluid reservoir connecting the plurality of channels of substantially all said plurality of multi-jet generators for providing a stream of said printing fluid to each of said plurality of channels;
  - c. a vibration unit for generating a pressure perturbation in each of said plurality of channels of said plurality of multi-jet generators whereby said printing fluid jet forms a plurality of printing fluid droplets; and
  - 25 d. a printing fluid droplets deviation unit operative downstream said plurality of multi-jet generators for deviating selected ones of said printing fluid droplets from said predetermined direction,
- 30

thereby forming a pattern of said printing fluid droplets forming an image on a printing substrate.

21. A printing apparatus according to claim 20 wherein each said channel comprises an inlet section having a narrowed section in an outlet end thereof for increasing stream velocity downstream therefrom, an outlet section having an aperture, and a chamber disposed between said narrowed section and said aperture for generating a jet of printing fluid from said stream of printing fluid.
22. A printing apparatus according to claim 20 wherein said printing fluid reservoir and said plurality of channels are generally perpendicular.
23. A printing apparatus according to claim 20 wherein said vibration unit is operative to vibrate said printing apparatus, thereby shaking said printing fluid, wherein said shaking generates said pressure perturbation.
24. A printing apparatus according to claim 23 wherein said vibration unit comprises:
  - a. a first plate connected to said at least one plurality of multi-jet generators;
  - b. a second plate;
  - c. a plurality of mountings disposed intermediate said first plate and said second plate; and
  - d. a piezoelectric transducer also disposed intermediate said first plate and said second plate,  
wherein the natural frequency of said plurality of mountings is smaller than that of said piezoelectric transducer.
25. A printing apparatus according to claim 20 wherein said vibration unit is an external piezoelectric transducer operative to vibrate said printing fluid in said printing fluid reservoir.
26. A printing apparatus according to claim 20 wherein said vibration unit comprises a piezoelectric transducer external to said printing fluid reservoir and operative to vibrate a pedal within said printing fluid reservoir.

27. A printing apparatus according to claim 20 wherein said droplets deviation unit comprises:

- a. a charging unit for charging selected ones of said printing fluid droplet not included in said pattern; and
- 5 b. a deflection unit for deflecting said charged printing fluid droplets from said predetermined direction.

28. A printing fluid channel according to claim 9 wherein said aperture is substantially smaller than said narrowed section.

10 29. A printing fluid multi-jet generator according to claim 12 wherein said aperture is substantially smaller than said narrowed section.

30. A printing apparatus according to claim 21 wherein said aperture is substantially smaller than said narrowed section.

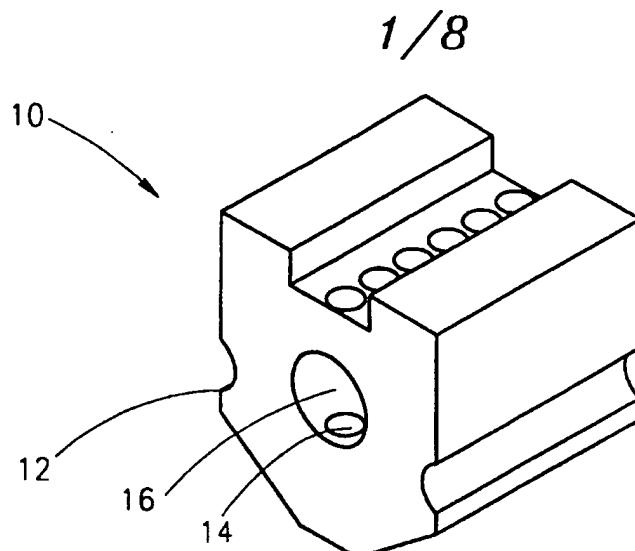


FIG. 1A

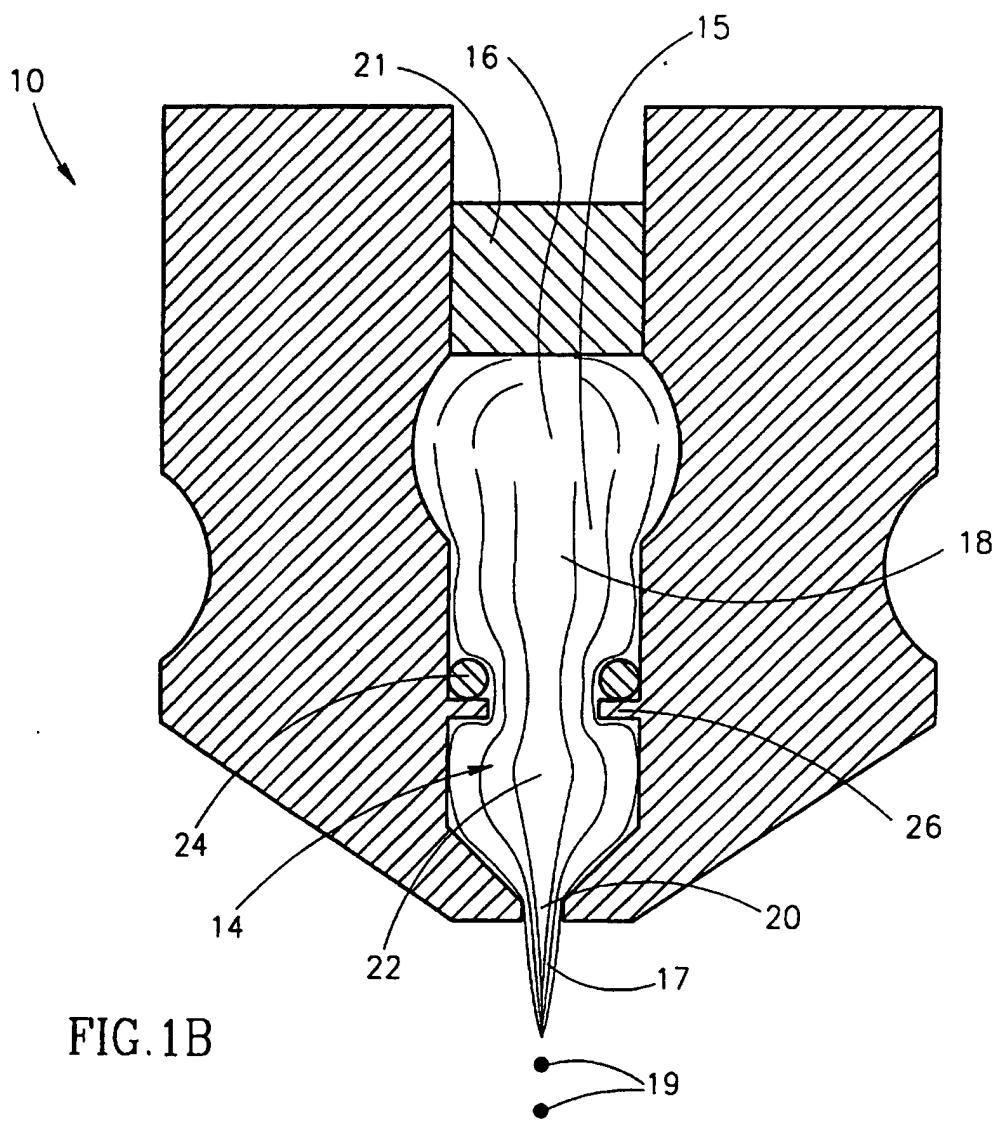
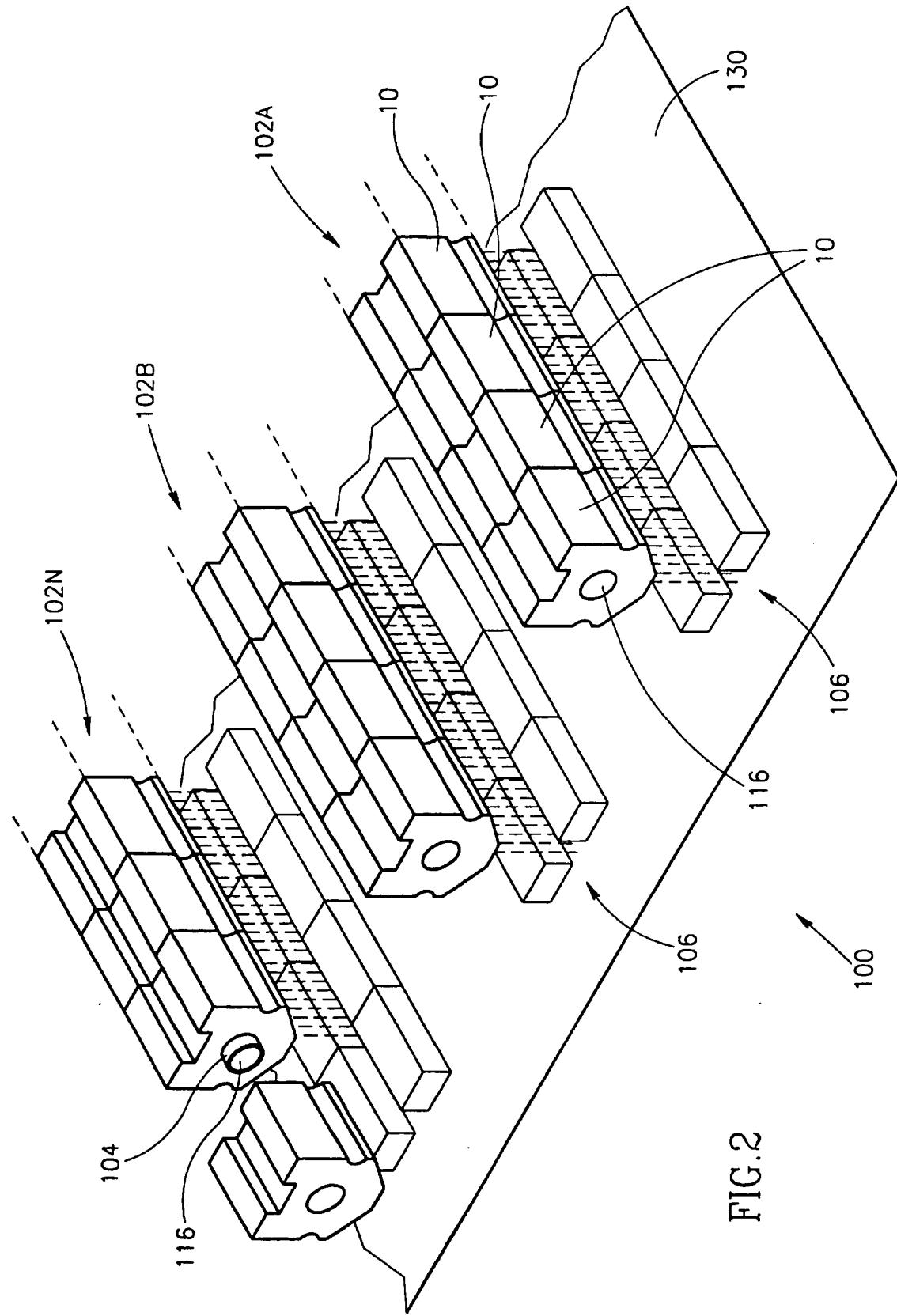


FIG. 1B

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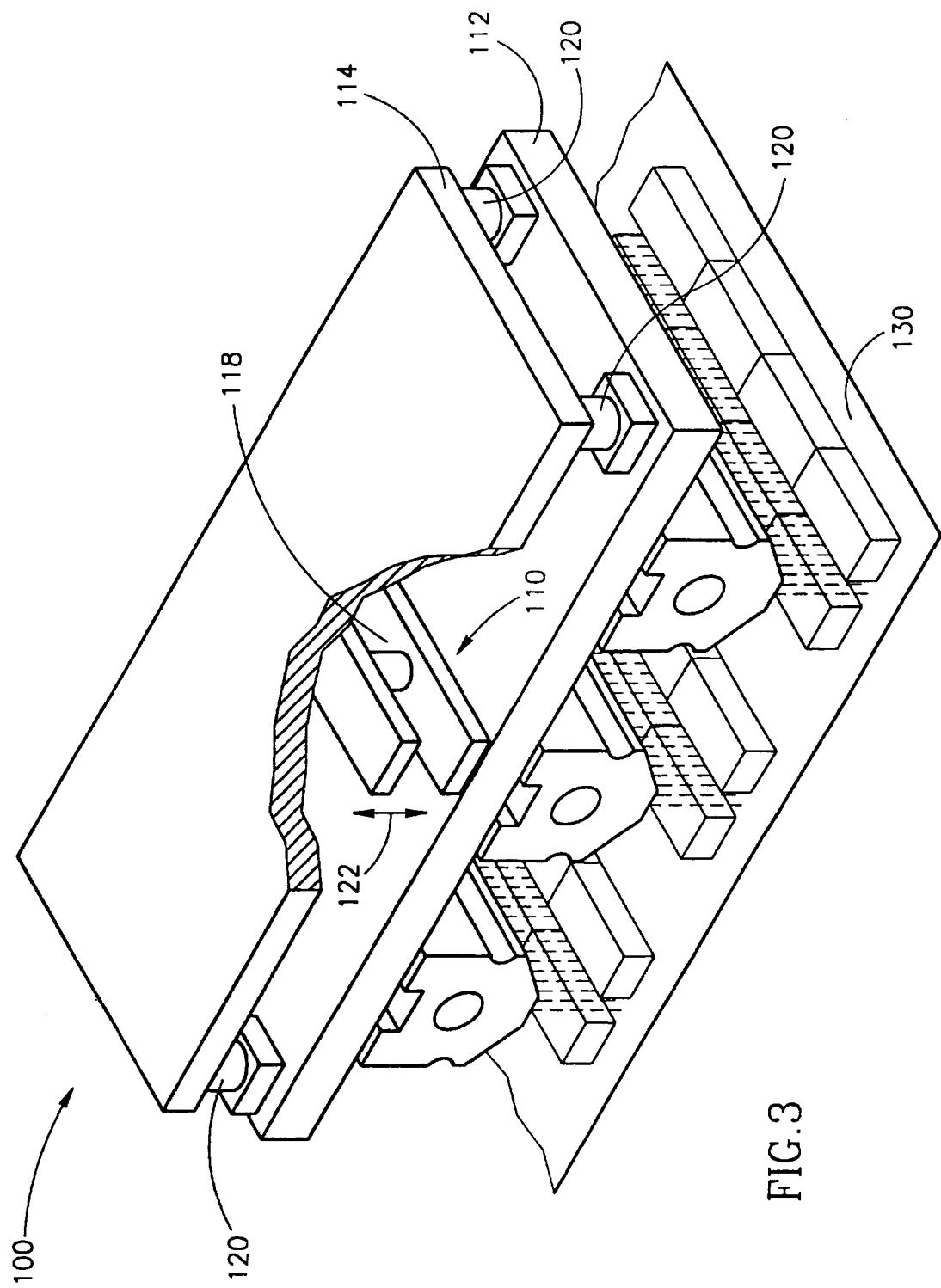


FIG. 3

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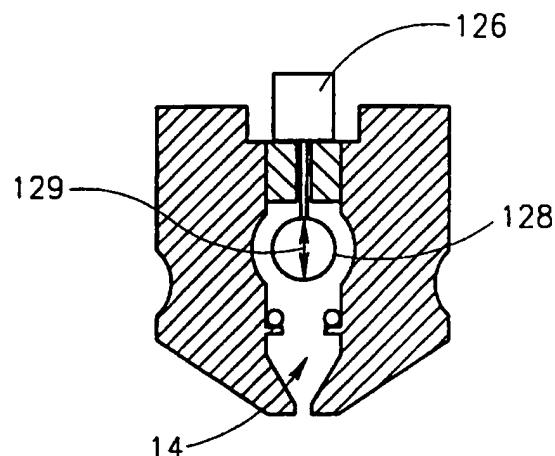


FIG. 4A

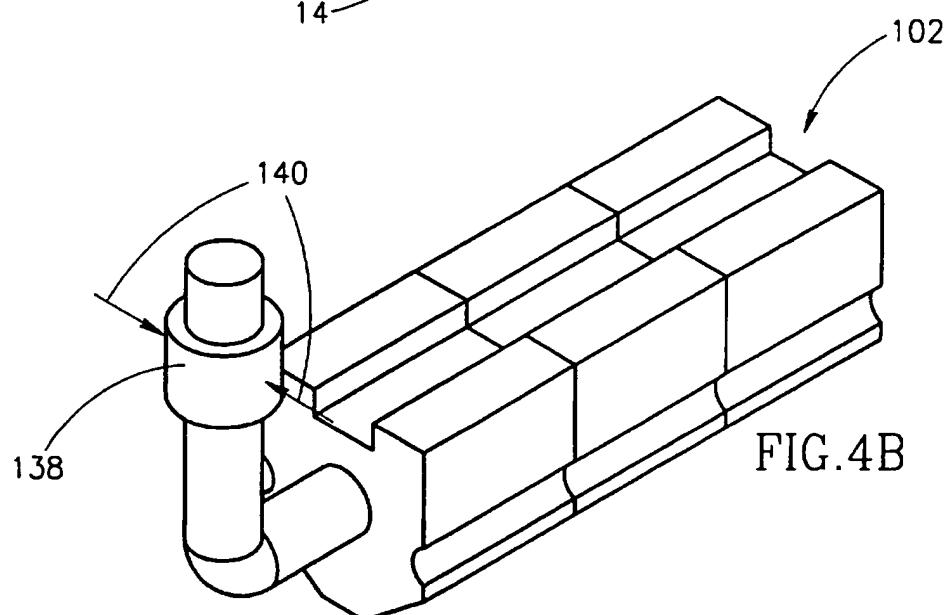


FIG. 4B

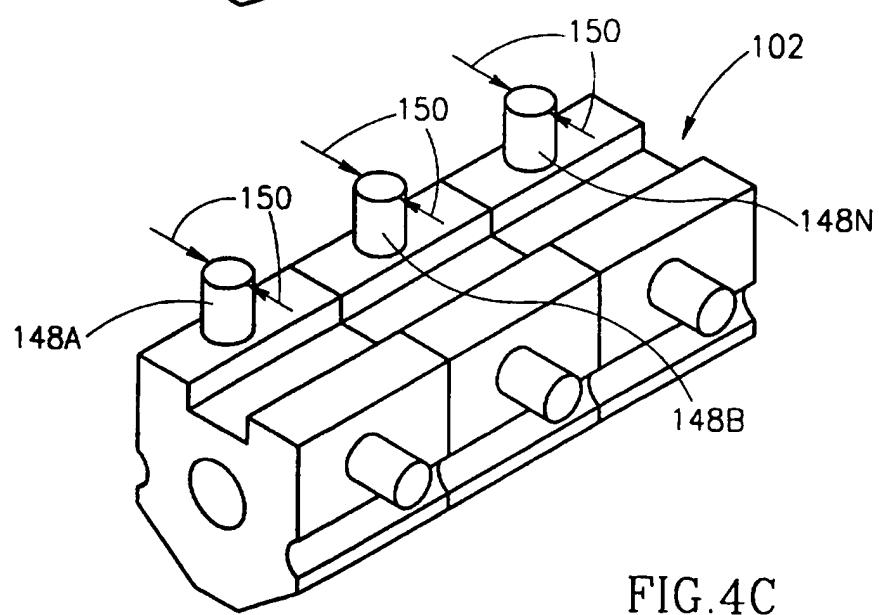


FIG. 4C

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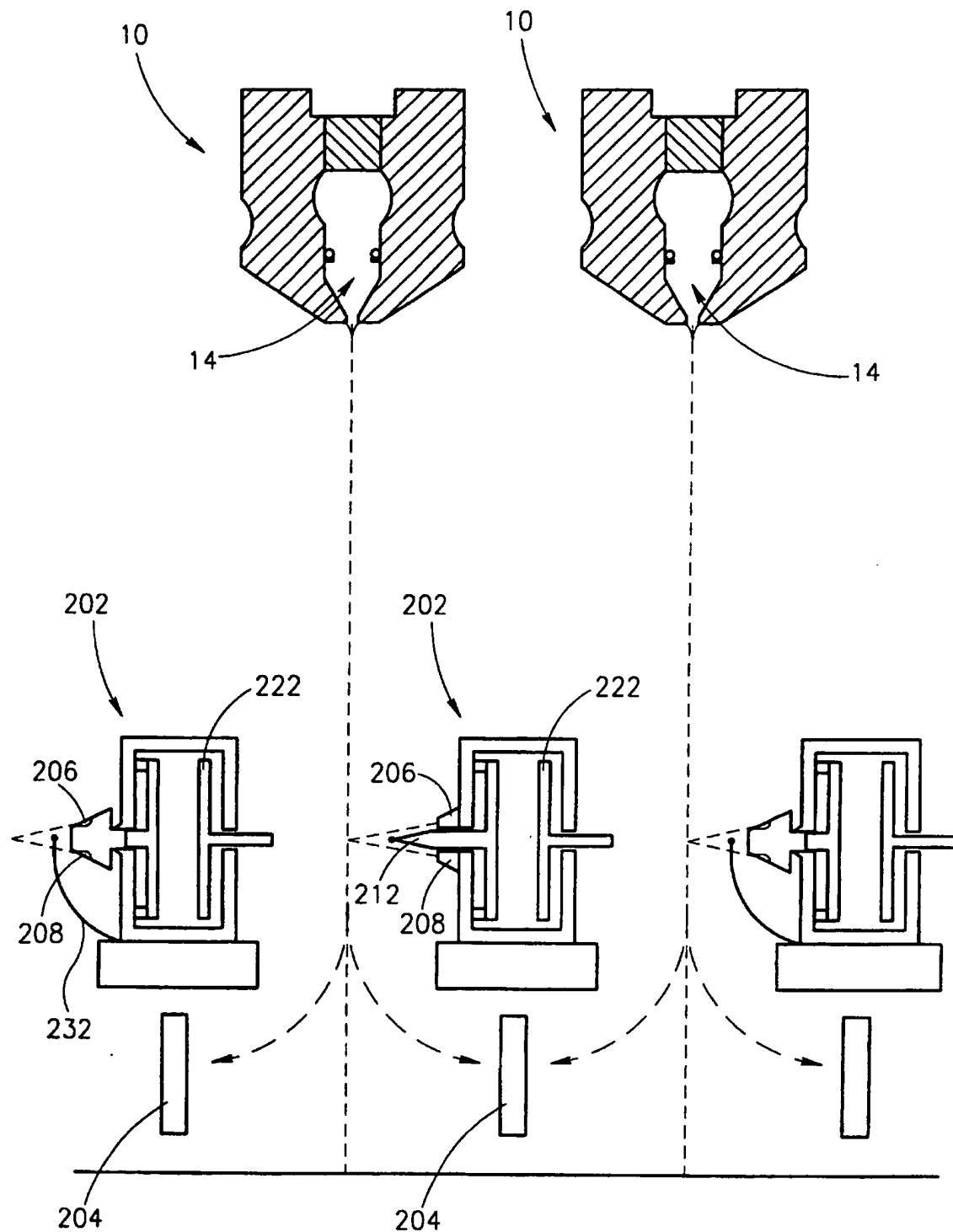
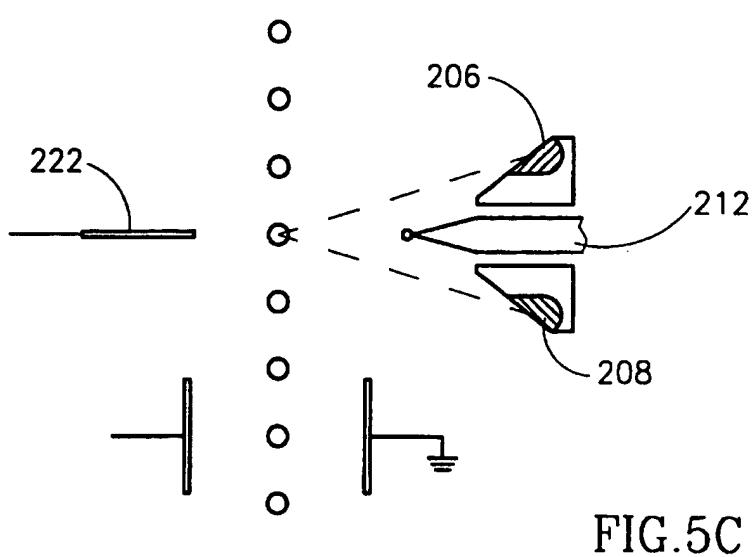
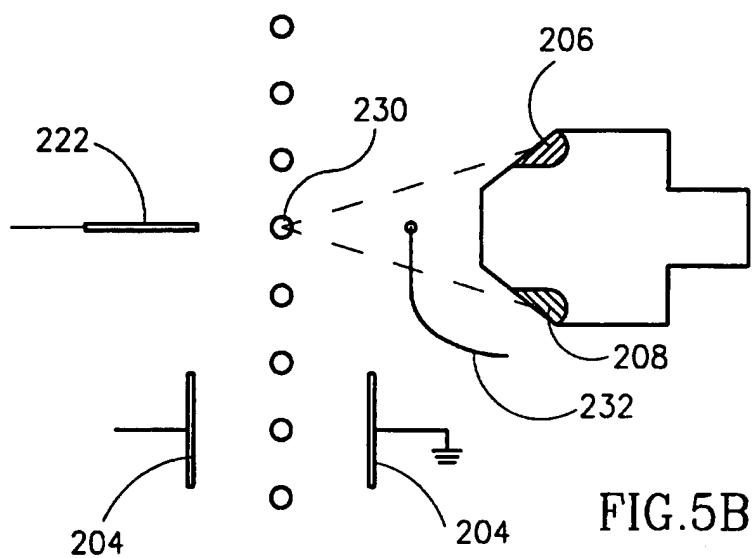


FIG.5A

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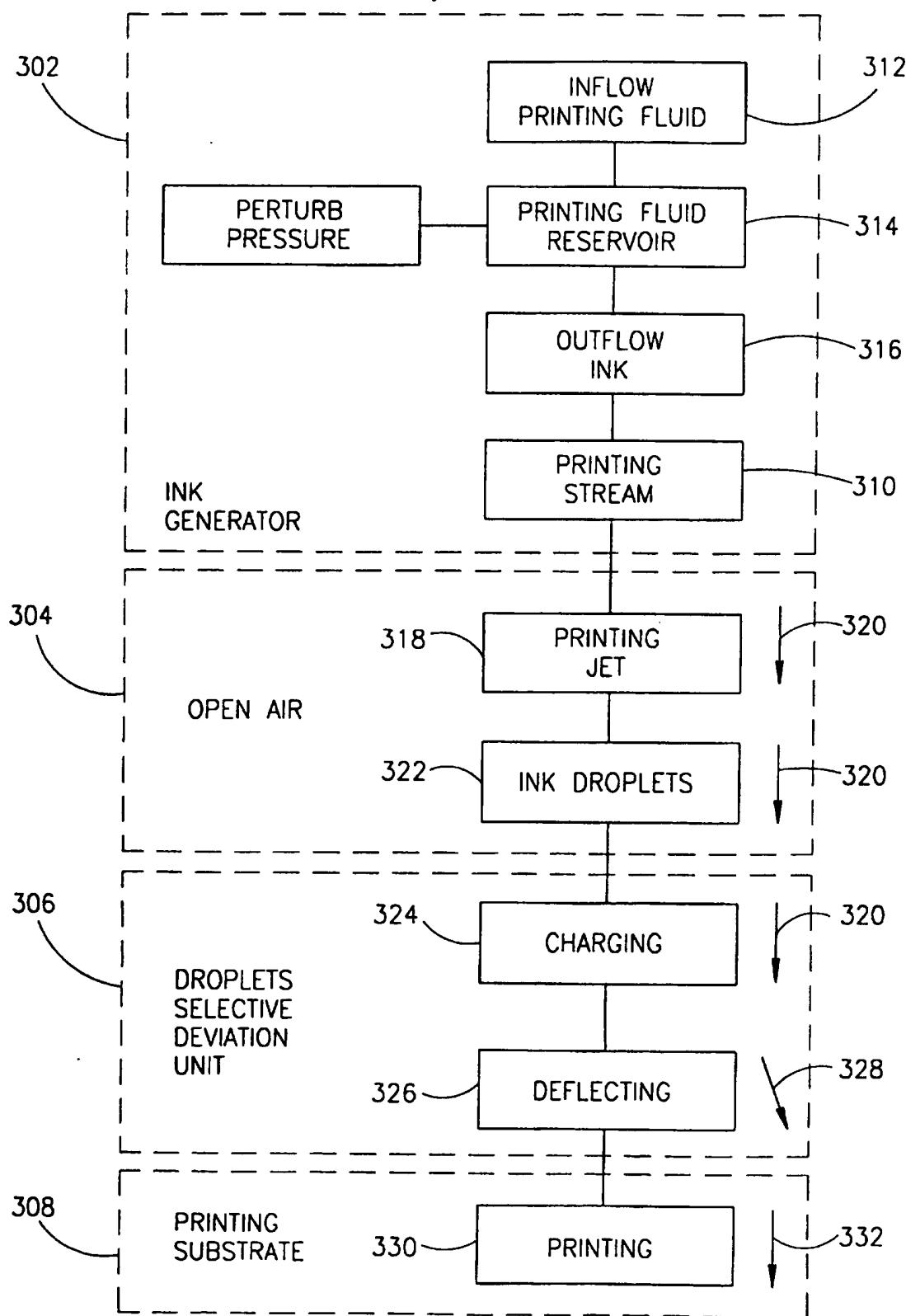


FIG.6

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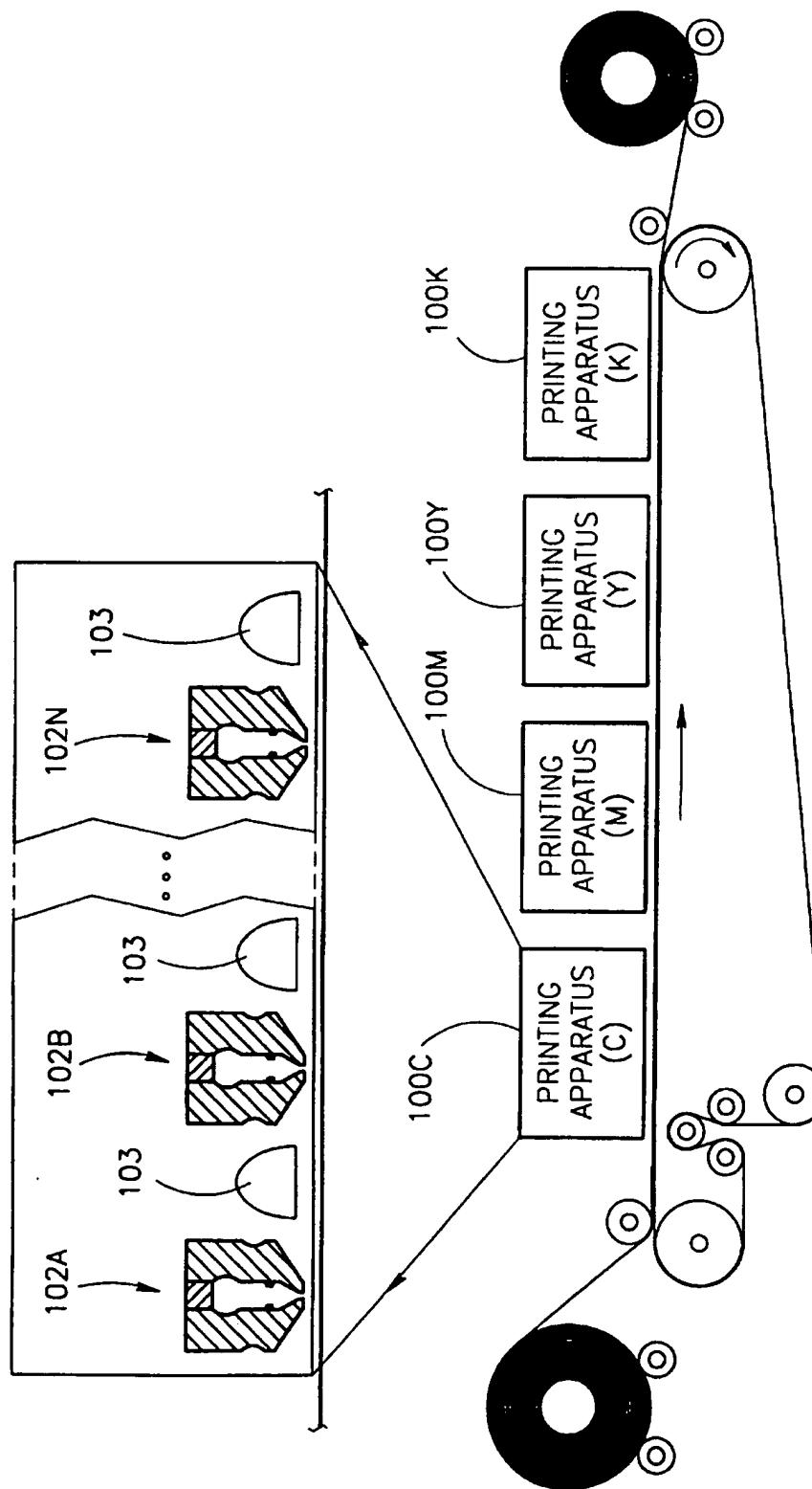


FIG. 7

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/IL97/00139

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B41J 2/02, 2/07, 2/045, 2/085, 2/14, 2/16  
 US CL : 347/72, 73, 74, 75, 76, 47, 48, 49

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 347/72, 73, 74, 75, 76, 47, 48, 49

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

N/A

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Extra Sheet.

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---	US 5,165,061 A (WITTEVEEN) 17 November 1992, See entire document.	10, 13-15, 29-30
Y		----- 1-8, 11-12, 16-28
X ---	US 4,384,295 A (LEWIS et al.) 17 May 1983, See column 3, lines 12-29; column 4, lines 26-36, 41-49.	9 ---
Y		1-6, 19-28, 31
Y	US 4,085,408 A (MUTO et al.) 18 April 1978, See column 10, lines 1-63; figures 6-8, 10, 12, 17.	7-8

Further documents are listed in the continuation of Box C.  See patent family annex.

* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*'A' document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*'E' earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*'L' document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
*'O' document referring to an oral disclosure, use, exhibition or other means		
*'P' document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
14 JULY 1997	15 AUG 1997

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer  THIEN-FRAN <sup>t</sup> / tylly/cj Telephone No. (703) 308-0080
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## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/IL97/00139

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,245,225 A (FILLMORE et al.) 13 January 1981, See figures 2-3	11, 18
Y	US 5,604,523 A (TSUKUDA et al.) 18 February 1997, See column 6, lines 28-30; figure 7B.	12, 16-17